Perceived Environmental Aesthetic Qualities Scale (PEAQS) : A self-report tool for the evaluation of green-blue spaces

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Perceived Environmental Aesthetic Qualities Scale (PEAQS) – a self-report tool for the evaluation of green-blue spaces

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Abstract:

Aesthetic qualities of urban green and blue spaces have received considerable attention in scientific literature but are operationalized in multiple ways and lack clear assessment and measurement techniques. To fill in this gap, we developed a Perceived Environmental Aesthetic Qualities Scale (PEAQS). Based on previous literature both in philosophy and empirical sciences we created a questionnaire with 36 statements and three open questions focusing on the perceived aesthetic qualities of environments. This questionnaire was used to sample 331 respondents in three sites different in their level of naturalness, human intervention and design: a natural-like but managed urban forest, a partly human-made and intensively managed bay-park and a completely human-made green roof. These sites were selected to represent a variety of urban green and blue infrastructure common in cities. The results suggest a scale that consists of 23 statements and five factors that reflect perceived aesthetic qualities of urban green spaces: Harmony, Mystery, Multisensority & Nature, Visual Spaciousness and Visual Diversity, and Sublimity. We give guidelines for further development and testing of the scale in order to prove its potential to develop the field of environmental aesthetics and to demonstrate its usefulness for adaptive, evidence-based urban planning and design.

1. Introduction

Green and blue infrastructure, including green and blue spaces, such as urban forests, parks, green roofs and open waters, provides not only regulating or provisioning ecosystem services (e.g. heat control or storm water management), but also cultural benefits and experiential qualities. The cultural ecosystem services include aesthetic ones that improve living environments and further, affect the health and well-being of citizens. (Clark et al., 2014; European Commision, 2013; Hoyle, Hitchmough, & Jorgensen, 2017; Jorgensen & Gobster, 2010; Lee, Williams, Sargent, Williams, & Johnson, 2015; Mesimäki, Hauru, Kotze, & Lehvävirta, 2017; Pazhouhanfar & Mustafa Kamal, 2014; Raymond et al., 2017; Velarde, Fry, & Tveit, 2007; WHO, 2005; Zinzi & Agnoli, 2012). For example, the role of aesthetics in relation to psychological well-being, restorative experiences and environmental preferences is described in Ulrich's (1983) Stress Reduction Theory (SRT) by assuming that the (aesthetic) perception of an environment is based on an evolutionary-driven, immediate, and unconsciously triggered affective response, such as preference, dislike or fear, when visually encountering environments. These responses, in turn, may affect the subsequent cognitive appraisal of the environment, physiological responses, behavior, and well-being.

Despite the idea of aesthetic benefits having been widely incorporated into urban planning and management, it is still not clear what is meant by aesthetic qualities, benefits and experiences, and a comprehensive comparative method to measure how people perceive these qualities is in high demand. In this paper, we clarify the conceptualisation related to aesthetics of green and blue spaces and identify experiences that we suggest to belong to the category of *perceived aesthetic qualities*. In this way we aim to characterize and operationalize *perceived aesthetic qualities*, and then develop a pilot version of a self-report scale to test whether these qualities can be assessed in a meaningful way in different types of green and blue spaces.

The need for developing tools to measure aesthetic qualities has been recognized in various

fields. For example, Stamatopoulou (2004) designed a scale to assess the components of aesthetic qualities of art, and more specifically, experiences triggered by the contemplation of works of art. Schindler and colleagues (2017) presented a tool that registers aesthetic emotions, triggered e.g. by music, paintings, and architecture. Closer to our area of research, Kirillova and Lehto (2015) introduced the Perceived Destination Aesthetic Qualities scale (PDAQ scale) that measures tourists' aesthetic judgement of leisure destinations. PDAQ scale emphasizes the novelty aspect, and is being best applied to novel and leisure environments in contrast to home conditions (Kirillova, Fu, Lehto, & Cai, 2014; Kirillova & Lehto, 2015). Furthermore, the scales measuring experienced restorative benefits of green and blue spaces include perceived responses to aesthetic qualities; the Perceived Restorativeness and Restorative Outcomes Scales measure fascination, i.e., the automatic interest and attention toward a pleasant environment, the urge to explore the surroundings and the experience of coherence (Han, 2003; Hartig, Korpela, Evans, & Gärling, 1997; Hartig, Lindblom, & Ovefelt, 1998; Korpela, Ylén, Tyrväinen, & Silvennoinen, 2008, 2010; Staats, Kieviet, & Hartig, 2003).

In the present study, we aim to develop a tool for evaluating several kinds of everyday green and blue environments from a user-centred point of view where the perception of the aesthetic qualities is central.

1.1 Characterizing perceived environmental aesthetic qualities

A wide range of disciplines, e.g. philosophy, psychology, landscape architecture and landscape preference research, study aesthetic qualities of environments. All these disciplines have given valuable, but also variable, insights into the topic, and clarifying these viewpoints is necessary before we can successfully operationalize and assess perceived aesthetic qualities.

Perceived aesthetic qualities have frequently been operationalized to cover only general

preferences or visual aspects. Firstly, environmental psychology and landscape research have frequently used the concept of preference that refers to direct and immediate liking and pleasantness, often using photos as surrogates, which does not reflect the "engaging" aesthetic qualities of the environment (see van den Berg, Koole, & van der Wulp, 2003; Berleant, 1992, 1995; Stamps ,1990). Secondly, according to e.g. Carlson (1977), Gobster, Nassauer, Daniel and Fry (2007), and Kirillova and Lehto (2015), visual or scenic beauty has been commonly used as a proxy to perceived aesthetic quality, even though it reflects only one type of aesthetic response to the environment (see also Brady, 2003, pp. 16-17; Hauru, 2015, p. 20; Kirillova et al., 2014). Even when environmental psychological and landscape studies do concentrate on multiple qualities of environments, the focus has often been on the visual, such as visual scale (reflecting e.g. openness and visibility in the landscape), complexity (visual diversity and complexity of patterns and shapes), mystery (promise of new information of vista) or coherence (unity of the scene, repeating patterns of colors and texture) (Tveit, Ode, & Fry, 2006). While these immediately experienced and visual aspects are important, they do not reflect the fact that environments are experienced with multiple senses.

Our starting point is that aesthetic qualities of environments are *perceived*. They are multisensory and context-dependent (Brady, 2003; Hauru, 2015; Hauru, Koskinen, Kotze, & Lehvävirta, 2014; Mesimäki et al., 2017; Nasar, 1988), and the information received by one or more of the senses may impact how the information received by the rest of the senses is processed (Lugten, Kang, Karacaoglu, Steemers, & White, 2018; Puyana Romero, Maffei, Brambilla, & Ciaburro, 2016; Van Renterghem, 2018) . They are also experienced within a place (i.e. not from a distance), and thus involve "engagement", which means that a perceiver is "immersed" in the environment (Berleant, 1992, 1995; Carlson & Berleant, 2004; Rolston, 1998). We focus on the *perceived aesthetic quality*, because that is the ultimate outcome of the person-environment interaction, and – taking a user-centred stance – is a key to evaluating the

environments created by planning, design or management processes. In other words, to learn about the aesthetic value of environments, we should collect data concerning the aesthetic experiences therein.

An extensive reading of literature (see the paragraphs below) suggested six major perceived environmental aesthetic qualities to be included in a scale that attempts to operationalise and measure the such virtues of urban green and blue spaces: perceived multisensory beauty, diversity, scale, coherence, mystery, and sublimity.

Beauty is a key concept in philosophical aesthetics, and it has been a matter of intellectual inquiry for western philosophers since Antiquity. The term 'beautiful' refers to what has traditionally been regarded as "aesthetically good" or "(visually) attractive" (Carlson & Berleant, 2004; Lothian, 1999). We emphasize the multisensory nature of the perceived aesthetic experiences, and, accordingly, acknowledge that 'beautiful' can refer to other sensory domains besides sight. Clearly, sounds and auditory landscapes can be beautiful (see also Berleant, 1992, 1995; Brady, 2003, p123-128; Chen, Adimo, & Bao, 2009; Hauru et al. 2014; Mesimäki et al., 2017).

Diversity or complexity as an aesthetic concept refers to richness and variety of e.g. structures, processes, patterns, shapes, sounds, smells and touchable features in the environment, and reflects the observational variety of things (Hauru et al., 2014; Blumentrath & Tveit, 2014; Kirillova et al., 2014). Diversity is an environmental quality that can both challenge and engage the perceiver. Depending on the nature and volume of the stimuli, integrating them all may be challenging but also offer opportunities for satisfactory and rewarding immersion in the environment. Diversity also has the capacity to induce experiences of complexity and mystery to occur (mystery is dealt with as a separate quality below; Hauru et al., 2014; Kirillova et al., 2014; Tveit et al., 2006).

Scale has been an integral concept in visual landscape perception studies as well as in socio-evolutionary theories suggesting that open spaces (prospect) and hiding places (refuge) predict environmental preferences (Appleton, 1975; Nasar, Julian, Buchman, Humphreys, & Mrohaly, 1983; Rudell & Hammit, 1987). Scale can be considered as a property that reflects the size of the environment and the openness of views, referring to the immediate perceptions of scope, prospect, visual and functional accessibility, and spaciousness, which all play an important role in contextual and engaging aesthetic experiences (Brady 2003, 16-17; Coeterier, 1996; Grahn & Stigsdotter, 2010; Kirillova & Lehto, 2015; Ode & Fry, 2002; Tveit et al., 2006; Qiu & Nielsen, 2015).

The origin of *coherence* is in the Kaplan and Kaplan's (1989) informational model that explains environmental preferences by referring to the information we gain from environments to understand them. Coherence has been characterized in numerous ways, e.g. as reflecting unity, balance, harmony, orientation and legibility as well as understanding the wholeness of the place and its relatedness to oneself (Blumentrath & Tveit, 2014; Coeterier, 1996; Hauru et al., 2014; Hauru, Lehvävirta, Korpela, & Kotze, 2012; Kirillova et al., 2014; Peschardt & Stigsdotter, 2013; Sevenant & Antrop, 2009; Tenngart Ivarsson & Hagerhall, 2008; Tveit et al., 2006). Coherence is shown to be apparent in places that are easy to understand, that are ordered, and show repeating patterns and forms, but it may also occur in places that fit well to their surroundings (Berleant, 1992, 1995; Blumentrath & Tveit, 2014; Sevenant & Antrop, 2009; Tang, Sullivan, & Chang, 2015; Tenngart Ivarsson & Hagerhall, 2008).

Mystery is another quality mentioned in the Kaplans' (1989) preference theory, and it is related to perceiving complexity, attractiveness, feelings of excitement, and desire to explore the place (see also Hauru et al., 2014). Mystery can occur in many kinds of environments, e.g. both in visually closed and open environments, as well as diverse and more monotonic ones, but its benefical value depends on whether a person experiences it positively or negatively (see Herzog & Bryce,

126 2007). The desire to explore would emerge from the human need of making sense of the
127 environment, and the promise of new information therein, but negative feelings could arise e.g.
128 where possible danger is anticipated (Kaplan & Kaplan, 1982).

129

130 Finally, the sublime, another key concept in philosophical aesthetics, has traditionally been
131 related to great and powerful landscapes - such as waterfalls, mountains, and the starry sky - that
132 may cause awe, fascination or fear, or be beyond human comprehension (Budd, 2005; Shapsay,
133 2013; Nicholson, 1963; Webster, 2001). However, nowadays, with the rise of the aesthetics of
134 the everyday life (Haapala, 2005; Leddy, 2012; Saito, 2007), sublime qualities might be found
135 and explicated in more "modest" environments as well. If a person is able to immerse in, or
136 deeply engage with, a given environment, *sublimity* - characterized as genuinely fascinating,
137 owerwhelmingly incredible or great - will be present (Paden, Harmon, & Milling, 2013;
138 Shapshay, 2013).

139

140 In this study, our objective was to develop a first version of a Perceived Environmental Aesthetic
141 Qualities Scale (PEAQS), a self-report tool that can be used to empirically investigate the
142 experienced aesthetic qualities of different urban green and blue spaces. Based on the previous
143 literature (reviewed above) as well as our own studies (see section 2.2), we hypothesized that the
144 scale should cover multisensory beauty, diversity, coherence, scale, mystery, and sublimity.

145

146 **2. Methods**

147

148 *2.1. Study site selection*

149

The sites selected for this study are located in XXXX (blinded for review), cities that belong to the capital region of XXXX (blinded for review) that in 2015 had a population of 1,437,890 (supplementary material, Electronic Appendix A). We selected three sites to represent very different types of green and blue infrastructure: a green roof, an urban park by the bay, and a forest. As the aim of the study was to test and develop the method, not to study the qualities of particular site types, three distinctive sites were considered enough to identify possible gaps in the method and to test its ability to distinguish between different kinds of environments. We chose to collect data in a limited number of sites in order to achieve a sufficient sample per site.

The green roof on top of a single house, surrounded by other single houses and their yards is located in XXXX (blinded for review), in an area that at the time of data collection was newly built and used as a housing fair. There were two small meadows on the study roof, and the site was facing a green roof on a similar single house. There was also a terrace with a sunshade umbrella, two deck chairs, a large pot plant and a small whirlpool bath on the roof (Fig. 1). The popular park by XXXX (blinded for review), (hereafter bay-park) is located right at the centre of XXXX (blinded for review). It is a managed but not very decorative or formal park, next to important buildings. The observed landscape opens up towards the bay and includes water, a dock, a foliage of trees and shoreline vegetation, e.g. reeds. An amusement park and the XXXX (blinded for review) are also visible at the background of the site (Fig. 2). The third site, in the southern part of the Central Park XXXX (blinded for review), is also popular among recreationists and commuters. It is a spruce-pine dominated woodland area with a full canopy cover and *Myrtillus*-type undergrowth (hereafter urban forest, Fig. 3).

Figure 1. Pictures of the Green Roof. Photo credits: Taina Suonio

Figure 2. Picture of the Bay-Park. Photo credits: Taina Suonio

Figure 3. Picture of the Urban Forest. Photo credits: Taina Suonio

These three sites offered a variety of environmental properties and design: the degree of naturalness versus built green (urban forest being the most and green roof being the least natural-like), human intervention (lightly managed urban forest, intensively managed bay-park and very intensively managed green roof), height (green roof on top of a building, bay-park and urban forest at the ground level), size and scale (green roof being a small and closed area with a visual

202 access to the surroundings, bay-park being spacious and open with high levels of prospect and
203 good visibility, urban-forest being large, but with relatively closed visual accessibility due to the
204 trees that block the view), type of vegetation (meadow-like and rather ascetic on green roof, rich
205 and diverse including different ecosystems from mature trees to bed of reeds and flowering
206 plants on the shore in bay-park, and forest plant species in urban forest), and presence of water
207 (human-made whirlpool on green-roof though empty during data collection, natural-like bay in
208 bay-park, no water in urban forest). Including sites with different properties, we aimed at
209 capturing a wide variety of the perceived environmental aesthetic qualities presented in section
210 1.2.

211 *2.2 The questionnaire*

212 We compiled a set of statements that would measure the six perceived environmental aesthetic
213 qualities of green and blue spaces: multisensory beauty, diversity, coherence, scale, mystery, and
214 sublimity. We selected most of the statements (21 items) from questionnaires that we had used
215 earlier in our studies exploring experiential qualities in urban forests (Hauru et al., 2014, 2012;
216 Koskinen, 2013), urban parks (the authors, unpublished data), and on green roofs (Mesimäki et
217 al., 2019), and rephrased some of them to better meet this study's objectives. The rest of the
218 statements (15 items) were generated specifically for this study, based on the literature
219 introduced in section 1.1. During different phases of our current and previous studies, we
220 consulted experts from different fields (environmental psychologists, philosophers, a sociologist,
221 a landscape architect, a horticulturist, ecologists and environmental scientists) for content
222 validity and phrasing of each statement. We also tested the pilot versions of the scale with small
223 groups of environmental scientists, ecologists, random recreationists and upper comprehensive
224 school pupils.

225 We hypothesized that the statements would sufficiently operationalize the 6 qualities, see Table
226 1. The 36th statement, “I like this place”, was included in order to test whether the perceived

environmental aesthetic qualities correlate with preference. The statements were presented in a 1 to 7 Likert scale (agreement from 1= not at all, to 7= completely). We used 10 different versions of the questionnaire, each with a randomized order of the statements, so as to avoid bias due to order effect. We did not test for the possible order effect, which is thus included in the error variation in the statistical tests.

The questionnaire also included three open-ended questions to explore 1) disturbing things, 2) especially pleasing things, and 3) the feelings aroused by the environments. The free-form answers were meant to support or challenge the factors emerging from the factor analysis and to offer a possibility to capture qualities and perceptions not covered by the 36 statements. The results of the free-form answers are shown in the supplementary material (Electronic Appendix C).

Finally, we included a section for background information (gender, age, place of residence, duty/denomination/education, frequency of visits to the site, and frequency of visits to green areas), to get a profile of the respondents. The Finnish questionnaire was translated into English before analyses.

Table 1. *The 35 statements included in the questionnaire to operationalise the six perceived environmental aesthetic qualities, and the last 36th statement to measure preference . We used 10 different versions of the questionnaire, where the order of the statements was randomised.*

Multisensory beauty

1. It's beautiful here.
2. The view here is picturesque.
3. The soundscape here is pleasant.
4. The surface underneath my feet feels comfortable.
5. There is a nice/good smell here.

Diversity

6. The view here is diverse.
7. The soundscape here is varying.
8. There are many scents in the air.
9. There are many colors in this place.
10. The manifold materials here attract to touch and feel.
11. Nature is diverse here.

Coherence

12. Things here seem to be right in place.
13. The different parts of this place form a coherent whole.
14. It is easy to understand this place.
15. This place fits well with its surroundings.
16. This is a harmonious environment.

Scale

17. The scale of this place is pleasing for me.
18. This place is spacious.
19. The horizon here seems to be somewhere far away.
20. There is enough room here.
21. Visibility here is good.

Mystery

22. I feel like exploring this place.
23. This place is mysterious.
24. This environment could provide me with surprises.
25. This is an interesting place.
26. This is an exciting environment

Sublimity

27. This place is unique.
28. This place is striking.
29. Here I can clearly sense the presence of nature.
30. This place is unspeakably spectacular.
31. This place exudes a deep (sense of) peace.
32. This place is scary in a fascinating way.
33. In places like this, a person can perceive his/her smallness (in relation to all being).
34. This place awakens respect for nature in me.
35. There is something sublime and noble in this place.

36. I like this place.

2.3 Data collection

The data for the green roof was collected in 2015. During two days of a housing fare in July, from 10 a.m. to 6 p.m., all visitors to the roof were asked to participate. Data for the bay-park was generated in summer 2016, during one day in June and another in July, from 12 noon to 3.30 p.m. The visitors to the site were stopped at a frequently used walking and cycling route and asked to participate. For the urban forest, data was collected during three days in August 2016, between 2 and 9 p.m. To control for the effect of weather on our results, we conducted fieldwork only during comfortable weather (no rain or windiness).

2.4 The respondents

The final sample was composed of 331 participants: 173 visitors to green roof, 88 at bay-park and 70 at urban forest. 61% of the respondents were women, 34% were men and 5% did not answer to this question. The respondent's ages varied between 20 and 70 years, they had a variety of professions, and 88% of them lived in a big city (see more detailed information in supplementary material, Electronic Appendix D).

2.5 Data analyses

We ran an Exploratory Factor Analysis (EFA) using generalized least squares extraction and oblique rotation (Promax). We chose EFA as there was no previous testing of this set of statements. As all the statements of the scale refer to the psychological experience of being in a place, we expected the statements and the factors to correlate and thus, selected an oblique rotation allowing for correlations between factors. The factor solution of the EFA was first scanned to remove statements showing low factor loadings (< 0.30) and communalities, and multiple factor loadings. Thereafter, the shortened scale´s reliability (internal consistency, measured by Cronbach's alfa) and convergent validity, i.e., agreement with related concepts, were assessed (Trochim, 2000). For assessing convergent validity, an "overall PEAQS score", i.e. the mean value of all the statements of the scale, was used to predict preference (statement

36) in Linear Regression Analysis. Likewise, linear regression analyses were run to predict preference with the emerging sub-scales (i.e. factors) individually. For the regressions, the introduction method was "Enter". Finally, Analyses of Variance (ANOVA) were run to check whether there were statistically significant differences among the overall PEAQS score and the sub-scales' scores between the three study sites indicating discriminant validity of the scale. When finding differences, Cohen's *d* statistic was calculated to obtain the effect size of such differences, and interpreted with the following guidelines: $d = .20$, small; $d = .50$, moderate and $d = .80$, large (Cohen, 1988). All the statistical analyses were performed using IBM SPSS Statistics v. 24.

3. Results

3.1 Exploratory Factor Analysis suggested five factors

The Exploratory Factor Analysis (n = 331) revealed five factors that we named *Harmony* (8 statements), *Mystery* (5), *Multisensority & Nature* (4), *Visual Spaciousness & Visual Diversity* (3), and *Sublimity* (3 statements) (Table 2). The eigenvalues of the five factors were greater than 1, and together they explained 63.49% of the total variance in the dataset (KMO =.97; Bartlett's test = 7974.5; $p < 0.001$). Pre-extraction communalities of single statements ranged from 0.37 to 0.74. Factor solutions were quite similar for green roof and bay-park but less easy to interpret as items loaded less coherently and not in the same order as in the full sample solution. Furthermore, the factor solution for the urban forest tried to form 5 or 6 factors but the solution remained unreliable. Thus, we concentrate only on the full sample solution.

For the sub-scales, we selected statements with loadings > 0.30, *and* with clear conceptual relationships with the rest of the statements in each factor. Of the items loading > 0.30, we also excluded those redundant to the contents of the factor, e.g. items 4 and 9 referring to the ground surface and colours loading on the first factor as they might just represent concrete expressions of harmony and beauty (items 16 and 1) already present on factor 1. In addition to statements

293 with only low loadings, we also excluded those with high loadings on multiple factors. However,
294 statements 11, 22, 25 and 35 with moderate or large loadings on more than one factor were
295 retained because they made a relevant contribution to the conceptualisation of the solution.
296 Allowing double loadings is in line with our assumption that the factors reflecting the experience
297 of being in a place may not be completely independent of each other. For example, statement 11
298 reflects nature (Factor 3) while it also seems logical that it may simultaneously reflect harmony
299 (factor 1). Another example is statement 22 that loads on factors 1 and 2, and is conceptually
300 tightly connected to the notion of mystery and the items on factor 2. Subsequently, the
301 condensed version of the scale consisted of 23 statements and showed a high internal consistency
302 (for the full scale Cronbach´s $\alpha = 0.96$; for the sub-scales, see Table 2).

Table 2

The exploratory factor analysis solution with Promax rotation for the 35 statements of the scale. The highest loadings are bolded. Excluded statements are shown in the lower section of the table.

Statement	Harmony	Mystery	Multisensority & Nature	Visual spaciousness & Visual diversity	Sublimity
15. This place fits well with its surroundings.	**.828**	-.067	-.016	.031	-.077
14. It is easy to understand this place.	**.809**	-.010	-.037	.062	-.028
17. The scale of this place is pleasing for me.	**.786**	.014	-.064	.117	.035
12. Things here seem to be right in place.	**.738**	-.104	-.009	-.021	.188
16. This is a harmonious environment.	**.721**	-.144	.100	-.044	.180
13. The different parts of this place form a coherent whole.	**.644**	-.084	.115	-.026	.080
1. It's beautiful here.	**.619**	.028	.054	-.095	.205
25. This is an interesting place.	**.613**	.419	-.280	.060	.071
26. This is an exciting environment	-.015	**.693**	.027	.170	.010
23. This place is mysterious.	-.054	**.601**	.114	-.115	.262
22. I feel like exploring this place.	.524	**.542**	.011	-.142	-.051
10. The manifold materials here attract to touch and feel.	.298	**.497**	.011	.020	-.119
24. This environment could provide me with surprises.	.232	**.480**	.093	-.040	.056
33. In places like this a person can perceive his/her smallness (in relation to all being).	-.099	.239	**.640**	.009	.071
8. There are many scents in the air.	.254	.097	**.499**	-.013	-.056
11. Nature is diverse here.	.446	-.008	**.487**	.045	-.046
3. The soundscape here is pleasant.	.299	-.034	**.479**	-.083	.163
21. Visibility here is good.	-.033	-.041	.069	**.789**	-.077
18. This place is spacious.	.013	-.042	-.177	**.787**	.182
6. The view here is diverse.	.023	.122	.225	**.599**	-.065
28. This place is striking.	.119	-.010	-.014	.033	**.834**
35. There is something sublime and noble in this place.	.307	.105	.016	-.126	**.603**
30. This place is unspeakably spectacular.	.050	.163	.102	.087	**.595**
Cronbach's α	.92	.846	.830	.767	.893
Factor's eigenvalue (pre-rotation)	16.84	1.81	1.48	1.08	1.02
Explained variance by factor (%, post-rotation)	14.89	9.30	11.04	8.24	11.63
Excluded statements					
2. The view here is picturesque.	.322	-.164	.149	.169	.379
4. The surface underneath my feet feels comfortable.	.598	.140	.079	-.042	-.099
5. There is a nice/good smell here.	.512	.046	.374	-.118	-.108
7. The soundscape here is varying.	.181	.176	.294	.147	-.099
9. There are many colors in this place.	.313	.117	.116	.161	-.043
19. The horizon here seems to be somewhere far away.	-.118	.100	.357	.118	.176
20. There is enough room here.	.386	-.030	.141	.362	-.034

27. This place is unique.	.169	.219	.052	.223	.255
29. Here I can clearly sense the presence of nature.	.579	-.095	.389	.014	.026
31. This place exudes a deep (sense of) peace.	.222	.001	.379	-.019	.309
32. This place is scary in a fascinating way.	-.583	.630	.227	-.049	.017
34. This place awakens respect for nature in me.	.484	.024	.380	-.037	.075

Overall the PEAQS mean score was strongly correlated with preference ($r = .78$; $p < .001$), indicating that the scale explained a relevant amount of the variance in preference (61%). Pearson correlation coefficients between the sub-scales and preference ranged from 0.52 to 0.84, with $p < .001$ (see Electronic Appendix D). The multivariate regression that tested their predictive power also gave statistically significant results for preference $F(5,324) = 159.86$, $p < .001$ (Fig. 4).

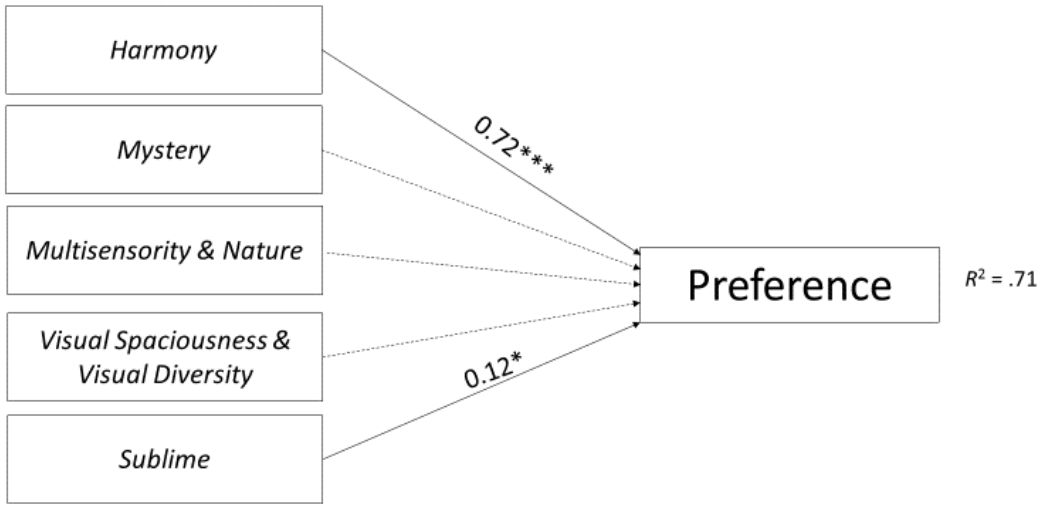

Figure 4. Regression model predicting preference by EAQS sub-scales. Numbers on the arrows represent the β (standardized regression coefficients) for each sub-scale with $p < .05$. R^2 stands for the amount of variance explained by the model. * = $p < .05$, *** = $p < .001$.

3.2 Differences in perceived aesthetic qualities between the study sites

309

310 The overall PEAQS score varied statistically significantly between the sites: *Post Hoc* testing
311 showed that visitors on green roof reported lower levels than those at bay-park or in urban forest
312 (Tukey´s HSD, Table 3). A main effect of the sites was also found for the five sub-scales (Table
313 3). Cohen's d varied from 0.61 (moderate) to 1.49 (large; Cohen, 1998). Visitors of green roof
314 reported lower levels of *Harmony* and *Sublimity* than participants in bay-park and urban forest.
315 *Mystery* and *Multisensority & Nature* were highest in urban-forest while *Visual Spaciousness &*
316 *Visual Diversity* was highest in bay-park.

Table 3

ANOVA results with the means (M) and standard deviations (SD) of the overall perceived aesthetic score and each sub-scale per study site. Tukey's HSD results show the pairwise comparisons of the means of the study sites, with statistically significant differences ($p < .05$) given with < or > to show which site had the higher mean score. d = effect size. GR = green roof, BP = bay-park, UF = urban forest

		ANOVA				**Tukey 's HSD Comparisons**		
Sub-scale		**Score (1-7)**		***F* (2, 327)**	***p***	**Tukey HSD**	***p***	***d***
	Site	***M***	***SD***					
PEAQS (overall score)	GR	4.01	0.99	42.83	< .001	GR<BP	< .001	1
	BP	4.94	0.87			GR<UF	< .001	1.13
	UF	5.13	0.99			BP UF	.137	-
Harmony	GR	4.36	1.09	72.63	< .001	GR<BP	< .001	1.24
	BP	5.56	0.83			GR<UF	< .001	1.42
	UF	5.81	0.95			BP UF	.271	-
Mystery	GR	4.01	1.16	19.30	< .001	GR BP	.318	-
	BP	4.23	1.26			GR<UF	< .001	0.94
	UF	5.02	0.98			BP<UF	< .001	0.70
Multisensority & Nature	GR	3.51	1.16	65.31	< .001	GR<BP	< .001	0.96
	BP	4.56	1.02			GR<UF	< .001	1.49
	UF	5.21	1.12			BP<UF	.001	0.61
Visual Spaciousness & Visual Diversity	GR	4.86	1.17	15.17	< .001	GR<BP	< .001	0.70
	BP	5.60	0.93			GR UF	.764	-
	UF	4.75	1.22			BP>UF	< .001	0.78
Sublimity	GR	3.32	1.26	56.93	< .001	GR<BP	< .001	1.19
	BP	4.83	1.27			GR<UF	< .001	1.15
	UF	4.87	1.42			BP UF	.984	-

4. Discussion

Below, we discuss the results of the Factor analysis and the free-form answers jointly, reflecting where the free-form answers provided support to the results based on the statements, or offered ideas for further development of the PEAQS.

4.1 A Perceived Environmental Aesthetic Qualities Scale

Based on our approach that drew from diverse theoretical and empirical literature, the 23-statement PEAQS revealed five perceived aesthetic qualities - *Harmony, Mystery, Multisensority & Nature, Visual Spaciousness & Visual Diversity*, and *Sublimity.* The scale showed good internal consistency and a factor structure accounting for a large proportion of the variance. Most of the qualities met our *a priori* expectations (see Table 1), however, the combinations of statements within some qualities deviated from what we had expected. This means that even though we carefully considered each statement with experts, and based them on a large set of literature, the sub-scales' contents (i.e. the set of necessary and sufficient statements and their exact formulation) should be refined for the next versions of the scale.

PEAQS succeeded in predicting preference, indicating convergent validity. The emerging factors were positively correlated to preference scores (r = .52-.84) and altogether explained a considerable share of the variance (61%). The size of these associations is similar to the ones obtained in other studies using informative variables (Stamps, 2004) and environmental affective responses (Galindo & Corraliza, 2012) but greater than those reported in studies using place attachment (Jaskiewicz, 2015) and familiarity (Hernández, Hidalgo, Berto, & Peron, 2001) as predictors. Furthermore, it showed discriminant validity by distinguishing between three different green spaces (one including also blue space). With PEAQS, we were able to sensibly characterize the aesthetic qualities of each environment: the green roof offered lower levels of *Harmony* and *Sublimity* than urban forest and bay-park, the urban forest scored highest in

343 *Mystery* and *Multisensority & Nature,* and *Visual Spaciousness & Visual Diversity* were highest
344 in bay-park. The differences were remarkable in size (d = 0.70 – 1.49).

345 All statements that we hypothesized to load on coherence did indeed load on the one factor, but
346 also statements reflecting beauty and interestedness loaded on the same one. This factor
347 entangles scale, unity and balance between the different parts of the perceived environment,
348 beauty and understandability, and also interest towards the place. We suggest that this
349 combination of items represents *Harmony* and propose an explanation for it based on
350 psychological processes: as beauty is experienced both cognitively and emotionally, beauty and
351 interest towards the observed environment combine together. Interest might be a predecessor as
352 well as a consequence of experiencing beauty (Leder, Belke, Oeberst, & Augustin, 2004). A
353 further reason for this combination can be found in the Stress Reduction Theory (Ulrich, 1983),
354 which states that environmental preferenda that are analyzed very rapidly include complexity,
355 focality, depth and ground surface texture. As a conclusion, we think that *Harmony* portrays a
356 space more specifically than the multifaceted concept "coherence" that has frequently been used
357 in landscape preference studies: as reviewed in section 1.2, coherence has been characterized in
358 multiple ways, and operationalizing it definitely needs more stringent conceptualization.

359 All statements that we hypothesized to load on *Mystery* did so, except the place being interesting
360 that loaded on *Harmony*. In addition, the statement "The manifold materials here attract to touch
361 and feel" (a priori hypothesized as a multisensory item) also loaded on *Mystery* and actually fits
362 well with its content, reflecting the multisensory side of this perceived aesthetic quality. *Mystery*
363 reflects excitement, desire for exploration and the place being tempting, and it has been shown to
364 be an important quality affecting preferences for natural environments also in many previous
365 studies (Kaplan & Kaplan, 1989 and studies thereafter; e.g. Gobster & Westphal, 2004;
366 Pazhouhanfar & Kamal, 2014). Also, the free-form answers reflected mystery and the place

being inviting for exploration. Thus, we suggest mystery to be an essential perceived aesthetic quality of green and blue spaces.

The *Multisensority & Nature* was an unexpected quality, combining statements measuring soundscape and scents (hypothesized to load on multisensory beauty), as well as diversity of nature (hypothesized to load on diversity), and perception of oneself being small in relation to all being (hypothesized to load on sublimity). It is an interesting combination but makes sense intuitively: nature can feed all senses and evoke a feeling of humbleness or relativeness (Olafsdottir, Cloke, & Vögele, 2017; Schroeder, 2007). This interpretation is supported by the free-form answers: both bay-park and urban forest gathered equally high numbers of mentions of nature, but yet the greatest proportion of mentions regarding senses other than visual was gathered in the forest, the most natural-like one of the study sites.

It may also be that multisensorial perception is "intrinsic" to all aesthetic qualities assessed *in situ*, as a person usually experiences an environment with all senses, not only by vision (see e.g. Brady, 2003, p. 123–128; Chen et al., 2009; Hauru et al., 2014), and therefore a "multisensory beauty" quality did not occur in our analysis. We suggest that the future versions of PEAQS should try to capture multisensorial aspects even better, by incorporating statements reflecting multiple senses into each quality.

Diversity did not form a distinct factor in our analysis but instead the statements hypothesized to load on diversity scattered among other qualities, or did not load on any factor, and were excluded. Instead, a factor that we interpreted as *Visual spaciousness & Visual diversity* comprised three statements that we *a priori* had assigned to the separate qualities of *diversity* (6., diverse view) and *scale* (16., spacious place; 21., good visibility. Logically, it was highest in bay-park, which was quite open, and visibly the most diverse of the study sites. Openness and diversity are qualities frequently present in previous landscape perception studies (e.g. Hauru et al., 2014; Kirillova et al., 2014; Ruddell & Hammitt, 1987; Ode & Fry 2002; Qiu & Nielsen,

2015), however, the association between these two qualities has not, to our knowledge, been much emphasized before. Nevertheless, the frequent mentions of space and visual diversity in the free-form answers suggest that statements operationalizing them should be included in the future development of the scale. Whether the combination of diversity and spaciousness is a general environmental aesthetic quality or a result due to the characteristics of our sites needs to be tested with a new data generation procedure that provides a sampling design that explicitly contrasts visual diversity with visual spaciousness.Moreover, related to the perception of space, the free-form responses also included mentions of height and position in relation to the observed environment, which should be considered in future versions of PEAQS.

Finally, *Sublimity* emerged as a separate quality, however, only three of the hypothesized statements loaded on this factor. Even though sublime characters have mostly been related to great and powerful landscapes, such as waterfalls or mountains (Shapsay 2013; Nicholson, 1963; Webster, 2001), we showed that the sublime can be experienced even in everyday environments, here in urban green and blue spaces. In philosophical aesthetics (e.g. Shapshay, 2013), the sublime is essential in aesthetic experiencing of natural environments, but to our knowledge, it has not been operationalized in empirical studies before. A reason for this might be that sublimity may be symbolic and quite abstract, and contains emotional and visceral responses towards the perceived (Shapsay, 2013), and is thus difficult to concretize.

4.2 Further development and applied value of PEAQS

While the 23-statement PEAQS extensively gathers aspects of the perceived environmental aesthetic qualities, there is still room for elaboration of its content. Also, the operationalization of the qualities (i.e. the statements) may need to be refined to accurately measure each quality. The relevance of the statements dismissed in this study could be re-evaluated after rephrasing them. One could also consider whether the factors could be measured with equal emphasis, i.e.

equal number of statements e.g. five-six, per factor, each including visual, auditory, olfactory and tactile senses where relevant.

Apart from re-elaborating some of the initially designed and current statements, there might be a need for the inclusion of further content. For instance, the sublime could include perspectives from psychology and applied aesthetics regarding transcendent or prototypical aesthetic emotions such as awe, being moved, and captivation (Joye & Dewitte, 2016; Keltner & Haidt, 2003; Shiota, Keltner, & Mossman, 2007; Schindler et al. 2017). Furthermore, the findings based on the free-form answers also raised some issues to be considered, such as the experience of joy and other positive feelings, frequently mentioned in our data. Aesthetic joy and delight have in fact been used to conceptualize positive perceived environmental aesthetic qualities (e.g. Nohl, 2001; Paden at al., 2013; see also Schindler et al. 2017 who list pleasing feelings as part of the aesthetic emotions evoked by art), but on the other hand, good mood and delight may also be a *consequence* of positive perceptions of environmental aesthetic qualities. Hence, including statements on the qualities behind the experience of joy and mood-enhancement might also constitute a relevant step forward. Finally, some free-form answers dealt with negative outcomes concerning other users' behaviors (e.g. fast bikers), overcrowding, or noise. The inclusion of such disruptive elements might mean an improvement for PEAQS as well – however, adding negative statements is not advisable, as they may impact the factor analysis, so that the solution is related to the negative phrasing rather than the actual meaning of the statements (see Mesimäki et al. 2019).

Future work with the tool should comprise its use in a greater variety of settings (e.g. designed parks, blue corridors, green corridors, rain gardens and brown fields, to give a few examples). Similarly, the tool should be used in different weather conditions (weather during data collection in this study was dry and warm) in order to check whether it maintains its structure in different moments of the year and under different climatological conditions. On the other hand, if the

441 scale does not work in a similar manner in all weather conditions, it implies that weather may
442 modify the experience so that that the composition of perceived environmental aesthetic qualities
443 is different during different weathers. In order to answer to these questions, the further
444 development and testing of the tool we recommended in previous paragraphs should be
445 complemented with these latter suggestions.

446 Obviously, no environmental experience occurs in a vacuum and thus, the perceived
447 environmental aesthetic qualities are likely linked to other psycho-environmental processes.
448 Examples of likely important and interesting associations include psychological restoration from
449 attentional fatigue (Kaplan & Kaplan, 1989, Hartig et al., 1997, Attention Restoration Theory;
450 ART), place attachment or place memories (Ratcliffe & Korpela, 2016), and evaluation of the
451 benefits and risks in the environment (Orians & Heerwagen, 1992). Clearly, besides aesthetics,
452 studies in environmental psychology and social sciences are relevant when examining perceived
453 qualities of environments. Consequently, the paired use of PEAQS with other measures
454 operationalizing the above-mentioned processes is highly recommended.

455 The need for PEAQS is evident, as the benefits that the perceived aesthetic qualities provide, are
456 important ingredients of good quality environments promoting health and well-being (Clark et
457 al., 2014; Chan et al., 2012; Hoyle, Hitchmough, & Jorgensen, 2017; Jorgensen & Gobster,
458 2010;; Mesimäki et al., 2017; Raymond et al., 2017; Velarde, Fry, & Tveit, 2007; WHO, 2005).
459 PEAQS will be a usable tool for city planners and green space managers, but also for scientists
460 to address the challenges of describing, assessing and evaluating aesthetic qualities of different
461 types of environments. The academic field of environmental aesthetics still lacks consistent
462 conceptualization of the perceived environmental aesthetic qualities (see section 1.1 in this
463 paper), which has hindered their effective assessment by both scientists and green space planners
464 and managers. We believe that with the help of this tool, demarcating and assessing aesthetic
465 qualities will become easier and more precise.

In the urbanizing world (European Commission, 2015; UNDESA, 2012), nature-based solutions and ecosystem services are expected to provide livable environments, and help adapt to climate change. Continuous feedback from science to practice is needed to support development of cities. PEAQS can be one tool to promote user-centred planning and management, and applying it to practice is important for the following reasons: First, since there are widely documented discrepancies between designers' and users' tastes and preferences for environments, empirical evidence of local citizens' experiences in their surroundings is necessary in order to plan liveable cities for urbanites (Frank, Fürst, Koschke, Witt, & Makeschin, 2013; Hoffmann, Westermann, Kowarik, & Van der Meer, 2012; Kalivoda, Vojar, Skřivanová, & Zahradník, 2014). Second, as aesthetic benefits are often mentioned in the strategies and guidelines for urban green and blue spaces (City of Copenhagen, 2015; European Commission, 2015), well formulated operationalization of such benefits is needed for them to be meaningfully evaluated. Third, PEAQS can be used to follow the changes of a particular space, to track the evolution of its perceived aesthetic qualities through time and to take decisions to improve the users' experiences. Finally, it could be a tool to better understand and evaluate aesthetic ecosystem services and benefits (Frank et al., 2013).

5. Conclusions

With this study we aimed at developing a comprehensive self-report tool for the assessment of the aesthetic qualities of urban green and blue spaces. By integrating knowledge from different disciplines concerning the aesthetics of environments, we operationalized four aesthetic qualities: harmony, multisensority and perception of nature, visual spaciousness and diversity, and sublimity in three different kinds of green spaces. It also captured qualities beyond visual, thus we encourage future studies to incorporate multisensority into the tool more extensively.

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